The Implications of Frequently Encountered Grading Factors on the Processing Quality of Common Wheat

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ABSTRACT

Grading factors associated with adverse growing conditions in Canada and the United States affect the edibility and end-use performance of common wheat. Mycotoxins are associated with fungal infections like fusarium head blight and ergot. Mycotoxins partition themselves among wheat milling products, and are relatively stable throughout wheat end-use processing. Fusarium head blight also has adverse effects on wheat milling and baking performance. Mildew and smudge and black-point are common fungal infections that present no toxicological danger. Mildew is a marker of potential sprout damage. The quality effects of all three forms of damage are relatively minor except when infections are severe, but they are an impediment to marketing wheat because they are aesthetically unappealing. The orange wheat blossom midge, whose larvae feed on developing wheat kernels, can result in devastating yield losses and also impart nonfunctional gluten properties and unsatisfactory baking quality when damage is severe. Farmers can reduce yield losses and quality deterioration by timely application of insecticides. Hard vitreous kernel (HVK) limits have been in place in common wheat grades for many years because vitreousness is directly related to protein content. Aside from a slight effect on kernel hardness, the level of HVK is not associated with wheat processing quality, and is redundant when protein content guarantees are a part of wheat transactions. Frost damage is one of the most serious grading factors. Severely frosted wheat is very hard, making reduction into flour difficult. Flour refinement and baking performance are also adversely affected. Pre-harvest sprouting causes processing problems because of high levels of the starch degrading enzyme α-amylase. The action of the enzyme during baking reduces the water holding capacity of the starch, resulting in lower baking absorption (lower bread yield) and handling problems due to sticky dough properties. In years of wet harvest improper use of hot air dryers can damage gluten functionality and baking quality without visibly altering wheat appearance. Rapid tests are available to detect gluten damage due to improper drying.

INTRODUCTION

One of the most important factors determining the processing value of wheat is physical condition (Dexter and Tipples 1987, Dexter 1993). Accordingly, most wheat producing countries have grading and classification systems in place that are intended to assign and preserve the commercial value of wheat parcels on the basis of processing potential, while also satisfying producers by giving the best possible return.

If a wheat grading and classification system is to be meaningful, it must have a scientific basis. In Canada the scientific basis for wheat grading and classification comes from research investigations conducted by the Grain Research Laboratory (GRL) and Industry Services divisions of the Canadian Grain Commission (CGC). These investigations document the effects on wheat end-use quality of grading factors at various levels and degrees of severity, to ensure that Canadian wheat grade tolerances are realistic. This article highlights the results of CGC research on frequently encountered wheat grading factors that affect edibility (ergot, Fusarium head blight) and processing performance (orange wheat blossom midge, hard vitreous kernels, frost damage, sprout damage, heat damage, mildew and smudge and black-point), and assesses the significance of each grading factor on milling and end-product quality.

FACTORS AFFECTING EDIBILITY

Ergot

Ergot is a fungal parasite (*Claviceps purpurea*) of cereals and grasses (Lorenz 1979). Infection takes place at the flowering stage, the ergot body growing in place of the kernel. Ergot contains alkaloids, which may be toxic when ingested by animals, poultry or humans (Mantle 1977a,b).

In recognition of its toxicity, strict tolerances for ergot are universally required when marketing wheat. However, there have been relatively few studies on the retention and stability of ergot alkaloids in flour mill streams and processed wheat end-products. Scott et al. (1992) reported that low levels of ergot alkaloids are prevalent in Canadian cereal products, with rye flour being the most contaminated.

Fajardo et al. (1995) determined the distribution of ergot alkaloids in individual millstreams from a pilot-scale milling of Canada Western Red Spring (CWRS) wheat containing 0.03% ergot (the maximum allowed for the No 3 grade is 0.04%). As seen in Table 1 they showed that ergot alkaloids are partitioned in variable concentrations among millstreams. Ergot is more plastic than hard wheat endosperm, hence it is flattened during smooth roll grinding. As a result, the ergot alkaloids tend to concentrate in late reduction streams and shorts derived from the reduction system. Ergot alkaloids are quite stable during end-use processing (Fajardo et al. 1995). Processing of flour into pasta and Oriental noodles has little effect on levels of ergot alkaloids, and a substantial proportion of alkaloids are still present after cooking. Processing flour into pan bread has a

minimal effect on alkaloid levels, although less alkaloids are present in the crust than the crumb.

These results demonstrate the complexity of predicting the concentration of ergot alkaloids in wheat flour and end-products. The concentration will depend on extraction rate, milling technique (grinding conditions and mill flow) and the component streams of a given divide flour. The variable stability of the alkaloids among final end-products further underline the complexities of establishing safe tolerance limits for ergot.

Fusarium Head Blight

Fusarium head blight (or scab) occurs worldwide on small grain cereals (Parry et al. 1995). Fusarium head blight outbreaks are a health concern because of the mycotoxins found in *Fusarium*-infected grain. Accordingly, there have been numerous studies focusing on the level of mycotoxins, particularly the trichothecene deoxynivalenol (DON, vomitoxin) in infected wheat, flour, and processed products (Pomeranz et al. 1990 and references therein, Tkachuk et al. 1991a, Trigo-Stockli et al. 1996). There is general agreement that DON is stable during wheat milling and secondary processing, although it becomes partitioned in varying concentrations among screenings, mill feed and flour streams (Table 2).

In addition to edibility problems, fusarium damage (FD) has a detrimental effect on the processing quality of wheat (Dexter et al. 1996 and references therein). According to Bechtel et al. (1985) *F. graminearum*, the most prevalent

species in the Great Northern Plains of North America, is an aggressive invader destroying starch granules, storage proteins, and cell walls. Boyacioglu and Hettiarachchy (1995) found that moderate *F. graminearum* infection causes significant compositional changes in carbohydrate, lipid, and protein in American hard red spring wheat.

FD reduces the milling performance of wheat (Tkachuk 1991a, Dexter et al. 1996). As seen in Table 3, FD results in lower test weight because of the shrunken nature of FD kernels. Flour yield and flour ash are affected slightly by FD, but the major impact on milling is a strong negative effect on flour brightness.

The effect of FD on baking quality is significant, but appears to be dependent on environment and variety. Seitz et al. (1986) concluded that scab levels up to 3% do not significantly affect hard red winter wheat baking quality. In contrast, Dexter et al. (1996) found that within the levels of FD encountered in southern Manitoba in 1994 there were highly significant effects (Table 3). One variety, Roblin, exhibited unacceptable baking performance even after fusarium-damaged kernels were removed. Baking strength index (Tipples and Kilborn 1974) which measures loaf volume potential at constant protein content is less than 80% of normal for Roblin even when severely FD kernels are removed.

Food safety remains the primary concern with FD wheat. However, the impact of FD on wheat processing potential cannot be ignored, and must be considered when establishing FD limits for wheat milling grades.

FACTORS AFFECTING PROCESSING PERFORMANCE

Orange wheat blossom midge

The orange wheat blossom midge (*Sitodiplosis mosellana* Géhin) is a prevalent pest in the wheat-growing areas of Europe and Asia. Periodic midge outbreaks are also common in the Great Northern Plains of North America, most recently in 1996.

Barnes (1956) has detailed the biology and life cycle of the orange wheat blossom midge. Eggs are deposited on the floret during heading and flowering, and the larvae feed on the developing grain. Severely damaged kernels are very light, and are lost during harvesting and grain cleaning. Lightly damaged kernels have a distorted shape, and often exhibit a split in the pericarp that gives the kernels a sprouted appearance.

Serious midge outbreaks have a devastating effect on crop yield. There are also reports that midge damage has serious effects on wheat milling and baking performance (Fritzshe and Wolffgang 1959, Miller and Halton 1961, Dexter et al. 1987). Grain from midge-damaged wheat exhibits unusually high protein content, reduced flour yield, dark flour color, high flour ash, weak sticky dough properties and poor bread quality.

Although midge damage could lead to serious wheat quality problems in infested areas, it is unlikely to pose a significant problem to the overall quality of a wheat harvest. Midge outbreaks are localized and generally of short duration. There is a strong incentive for insecticide treatments to protect crop yield, and if timely, insecticide treatments can significantly reduce the extent of wheat quality

deterioration (Table 4). In areas where midge damage is extensive, the SDS-sedimentation test (Axford et al. 1978), a rapid simple estimate of gluten strength, can be used to screen for the adverse effect of midge damage on gluten properties (Dexter et al. 1987).

Hard vitreous kernels

Hard vitreous kernel (HVK) content is a widely used specification in the grading and marketing of hard wheats. The CGC defines hard vitreous kernels as those having 'a natural translucent coloring which is an externally visible sign of hardness'. Kernels having a starch spot of any size are considered to be non-vitreous (also known as starchy, yellow berry or mealy kernels).

Several factors influence the degree to which wheat becomes non-vitreous, including weather conditions, soil fertility and heredity (Phillips and Niernberger 1976). It is generally accepted that the primary effect of HVK on wheat quality is a direct relationship between vitreousness and protein content (Pomeranz et al. 1976, Simmonds 1974). Pomeranz et al. (1976) showed that protein quality is not affected because HVK and loaf volume are unrelated when protein content is held constant.

A secondary effect of HVK is a positive correlation to kernel hardness (Pomeranz et al. 1976) The softer nature of nonvitreous wheat is due to a less extensive gluten protein matrix which results in weaker protein-starch adhesion within the endosperm (Simmonds 1974). Phillips and Nierberger concluded that degree of vitreousness has no effect on milling yield. Work done in our

laboratory confirmed that for hand-picked samples exhibiting variable degree of vitreousness there is an effect on kernel hardness as evident by a change in particle size index (based on the concept of break release) measured as described by Williams and Sobering (1986) (Table 5). The effect is so slight that intrinsic hardness differences among wheat classes are readily discernible for piebald (partly vitreous) kernels. There is some overlap in hardness between classes when kernels are fully starchy, but for North American hard wheat fully starchy kernels rarely comprise a major proportion of commercial wheat samples.

Protein content of wheat can be easily, precisely and objectively measured. In contrast, HVK determination is tedious and subjective. Increasingly protein guarantees are a prerequisite for marketing wheat which may make HVK a redundant quality factor.

Frost damage

The short growing season in western Canada and the northern United States makes frost damage a common grading factor. The severity of the quality effects of frost damage depends on the maturity of the grain when exposed to frost, the temperature to which the grain is exposed and the duration of exposure (Preston et al. 1991).

Severe frost damage is one of the most serious quality defects associated with wheat quality (Dexter et al. 1985 and references therein). Severe frost damage reduces flour milling value due to the combined effects of lower flour yield and poorer flour refinement (higher four ash and darker color) (Table 6). In addition,

severely frosted wheat is extremely hard, resulting in higher energy consumption during flour milling. Mill balance is also disrupted because the extreme hardness of middling stock results in a greater proportion of stock migrating to tail-end reduction passages. The extreme hardness of severely frosted wheat results in high flour starch damage.

Severely frosted wheat exhibits unsatisfactory physical dough properties (Table 6). Bread volume, appearance, crumb structure and crumb color deteriorate progressively as degree of frost damage increases.

The poor physical dough properties and baking quality of severely frozen wheat are attributable to inferior gluten properties (Dexter et al. 1985). When a killing frost occurs when the grain is physiologically immature, gluten protein synthesis is prematurely arrested and gluten functionality is adversely affected.

Frost damage in wheat is difficult to quantify, and is assessed by comparison to visual standard samples. However, experience at the CGC indicates that trained grain inspectors can precisely estimate the degree of frost damage, thereby protecting milling grades from the drastic quality effects of severe frost damage.

Sprout damage

Pre-harvest sprouting due to damp harvest conditions has little impact on milling properties, but can have serious adverse effects on bread quality (Chamberlain et al. 1983). Sprout damage is detrimental to bread quality because of the action of the starch degrading enzyme α-amylase which is present in very high levels in sprouted wheat (Kruger 1994).

As α-amylase degrades starch during mixing and fermentation, the water holding capacity of starch is reduced. Baking absorption must be reduced, lowering the number of loaves of bread obtained from a given weight of flour, an important economic consideration to bakers (Tipples et al. 1966, Tkachuk et al 1991b). Loaf volume often is not affected by sprout damage, and can actually increase due to more rapid gas production during fermentation (Ibrahim and D'Appolonia 1979). Sprout damage leads to sticky dough which causes handling problems, a more open coarse crumb structure and gummy crumb (Buchanan and Nicholas 1980, Moot and Every 1990). Gummy crumb causes build-up on slicer blades and interferes with effective bread slicing (Dexter 1993) (Fig. 1).

All of the effects of α-amylase are exaggerated for baking processes with long fermentation times because α-amylase continues to degrade starch during the fermentation stage. In the case of Oriental noodles dough is prepared at lower water absorption, preparation time is much less, and alkaline additives are often present which raise the dough pH well outside the optimum of most cereal enzymes. As a result the effects of sprout d. mage on noodle quality are so slight that they do not preclude the noodles from being marketable (Kruger et al. 1995).

Visual estimation of sprout damage gives only a rough indication of end-use quality effects because of the very heterogeneous distribution of α-amylase within individual wheat kernels and inconsistent retention of α-amylase activity among wheat exhibiting comparable degree of damage (Kruger and Tipples 1980). Alpha-amylase originates in the outer layers of the wheat kernel, so the enzyme

tends to concentrate in high ash streams during flour milling (Kruger 1981). As a result, the best prediction of end-use quality for a sprouted wheat sample is obtained when tests such as falling number, amylograph viscosity and assays for α-amylase activity are determined directly on the flour.

Heat damage

A problem frequently associated with wet harvests is heat damage caused by improper storage of damp grain or by artificial drying at too high a temperature. Damp grain may heat during storage, causing loss of gluten functionality. In extreme cases kernels turn black and emit a charred odor (binburnt kernels).

Binburnt grain does not pose a serious threat to wheat marketing because it is readily detectable visually. However, artificial drying at too high a temperature may damage gluten functionality with no visual evidence of heat damage. Heat damage has little effect on milling properties, but may have serious adverse effects on physical dough properties and end-product quality (Table 7).

Fortunately the wheat growing areas of North America are usually favorable for drying grain naturally in the field. Occasionally wet harvest conditions necessitates hot-air drying to reduce moisture content to levels acceptable for safe storage. To protect wheat processors rapid sensitive tests are needed to detect heat damage.

Physical dough properties are very sensitive indices of heat damage. The GRL uses changes in mixograph properties to detect heat damage in commercial samples during years of wet harvest. Sample pairs taken before and after drying

are milled by a rapid procedure, and mixograph curve shapes are compared (Kilborn and Aitken 1961, Preston et al. 1989). Any difference in mixograph curve shape indicates a change in gluten functionality, and provides a signal that dryer temperature must be reduced. Samples dried by farmers, private operators and terminal elevators are monitored.

Monitoring heat damage by physical dough properties is highly effective, but is relatively time consuming and requires expensive equipment and considerable technical expertise. More rapid procedures are needed to screen for heat damage in individual lots being discharged at a mill or storage facility.

Preston and Symons (1993) refer to a number of more rapid heat damage tests available based on enzyme inactivation, dye binding capacity, turbidity and protein extractablity, but all still require technical expertise and can be sensitive to cultivar and protein content. They have proposed a simple rapid test based on the formation of protein fibrils when a sample of ground grain is wetted. Seckinger and Wolf (1970) were the first to observe that wetting of thin sections or particles of wheat endosperm results in rapid formation of microscopic protein fibrils. Preston and Symons (1993) found that the extent of fibril formation viewed by bright field microscopy was highly sensitive to degree of heat damage (Fig. 2). Using their procedure all samples identified as seriously heat damaged by the mixograph procedure showed little or no fibril formation. The procedure shows great promise because it requires little technical training, and an inexpensive low power microscope gives satisfactory resolution.

Mildew

Mildew fungus (*Cladosporium*) is often associated with wet harvests. Mildew damage is characterized by grey tufts of spores at the distal ends of damaged kernels. Subjective estimation, based on overall sample appearance, is the only means of estimating moderate mildew damage.

Because mildew is associated with weathering and sprout damage, it is difficult to fully differentiate quality effects from those due to sprout damage. Severely mildewed kernels, which become blackened and rotten, are readily quantified, and should be tolerated in low amounts because of negative impact on flour brightness. At the GRL the effects of moderate mildew damage on soft wheat from Ontario demonstrate that as mildew increases test weight and Falling Number decrease, indicative of increased sprout damage (Table 8). Flour milling performance is lower because flour is darker. Effects on other quality factors such as alkaline water capacity, alveograph dough properties and cookie quality are slight.

Mildew does not pose a toxicological hazard. Although moderate mildew damage is apparently not a major quality factor, it serves as a very useful flag for wet harvest conditions and potential sprout damage. The discoloration of the seed coat also can be an aesthetic detriment to food applications like breakfast cereals.

Smudge and black-point

The fungi *Alternaria alternata* and *Helminthosporium sativum* are common sources of infection in wheat which give kernels a dark-brown or black

discoloration. When the infection is confined to the germ end it is referred to as "black-point". When the infection progresses along the crease discoloring more of the kernel it is referred to as "smudge". In western Canada *Alternaria alternata* is by far the most prevalent cause of infection.

Smudge is considered a serious quality factor because at that stage the infection has penetrated the endosperm causing discoloration of the flour. Studies at the GRL have concluded that the effect of black-point on wheat flour milling and baking quality are minimal, even at levels sufficiently high to down-grade wheat to Feed (Table 9). An Australian study reached similar conclusions (Rees et al. 1984).

Black-point and smudge pose no toxicological danger. Although black-point is a minor quality factor, it remains an important aesthetic grading factor because the poor appearance of wheat with black-point impedes marketing to demanding end-users. The discoloration of the germ and bran associated with the infection also are a detriment to production of germ and breakfast cereals.

CONCLUSIONS

It is important to realize that when wheat growing or harvesting conditions are poor resulting in physical damage, a properly developed grading system will protect the processing quality of the wheat. Numerical grading systems such as those used by Canada and the United States, which have constant grade

specifications year to year, insure that the quality of a given grade is consistent. In a bad year it is mainly the proportion of top-grade wheat that is reduced.

Grade specifications among wheat producing countries evolve in response to the implications of various grading factors on wheat milling and end-use quality. Millers can ensure that minimum quality standards will be met by specifying the appropriate grade. When the miller is not familiar with the relative quality of the milling grades being offered by the supplier, or if the supplier does not have a well developed grading system, the miller can demand that the supplier meet a list of specifications, thereby insuring that quality expectations are met.

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Figures

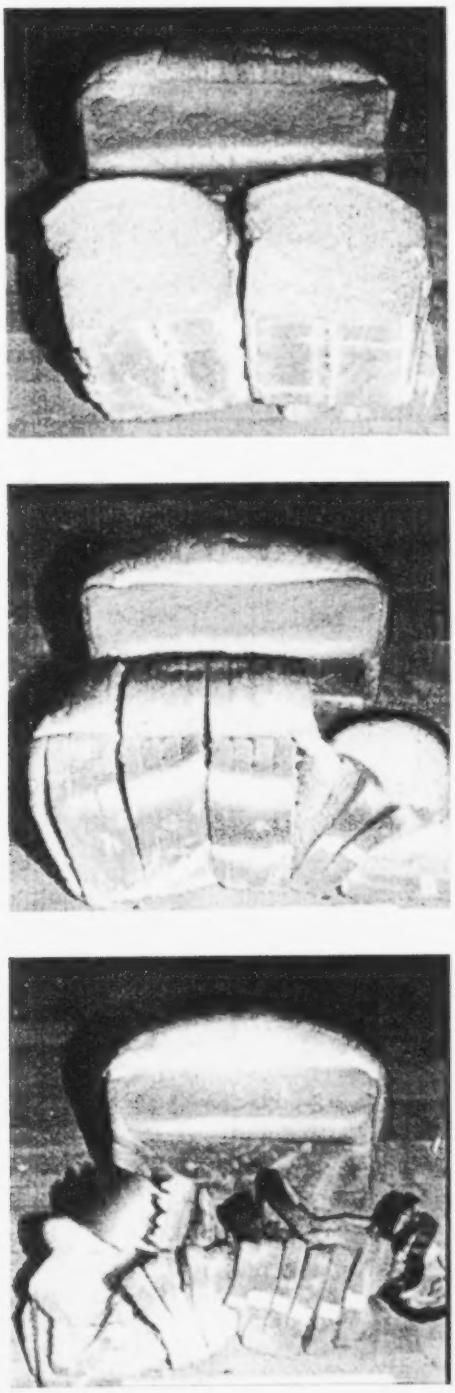

Figure 1. Potential bread waste from build-up on slicer blades due to gummy crumb of bread baked from sprouted wheat flour. Top, center and bottom loaves prepared from control, 3% germinated and 5% germinated wheat respectively (Dexter 1993).

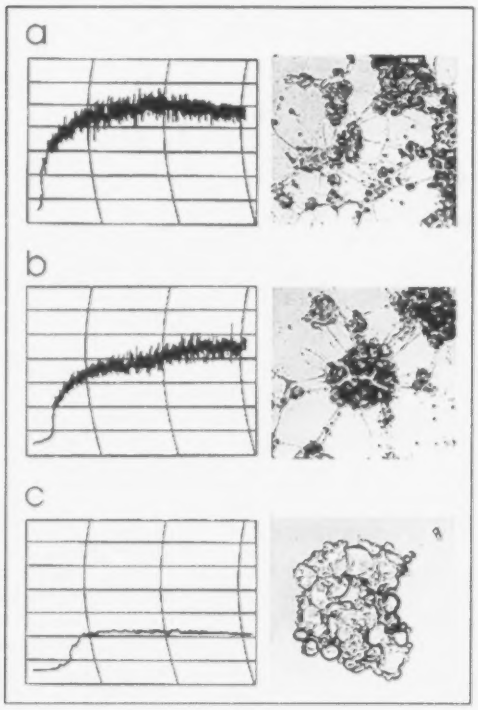

Figure 2. Mixograms and corresponding bright field photomicrographs of flour obtained from No.1 CWRS 12.5 wheat treated for (a) 0 hours, (b) 4 hours and (c) 16 hours at 70°C in sealed glass jars after tempering to 16.5% moisture for 16 hours. Adapted from Preston and Symons (1993).

Table 1.

Concentration of ergot alkaloids (ppb) in some millstreams from ergotic CWRS wheat.

Stream	Ash, %	Alkaloids, ppb
Millfeed:		
Red dog	2.72	4700
Bran	6.28	22
Flour:		
Middling 6	1.24	900
Middling 3	0.51	44
Bran flour	2.83	44
Break 3	0.58	27
Break 1	0.48	10
Middling 1	0.34	8

Source: Farjardo et al. (1995). Ash and alkaloid contents expressed on 14% moisture basis.

Table 2.

Concentration of vomitoxin (μg/g) in CWRS wheat, milled products and bread.

Product	Wheat A	Wheat B
Dirty wheat	7.1	1.4
Dockage	16.7	1.4
Clean wheat	4.6	1.8
Bran	4.2	1.8
Shorts	7.4	2.1
Red dog	5.6	2.0
Straight-grade flour	4.0	1.5
Bread	4.0	1.1

Source: Wheat A data from Scott et al (1983); wheat B data from Scott et al (1984). Bread data are expressed on equivalent flour basis.

Table 3.

Effect of fusarium damage on some quality properties of Grandin and Roblin hard red spring wheat..

Property	Grandin		Roblin	
	CL	AS	CL	AS
Wheat:				
Fusarium damage, %	1.5	7.3	0.2	5.9
DON, µg/g	1.7	8.0	1.2	9.5
Test weight, kg/hL	79.0	76.7	77.9	75.0
Protein, %	14.0	13.7	14.8	14.7
Flour yield, %	75.0	74.7	74.1	73.5
Flour:				
Ash, %	0.50	0.52	0.49	0.52
Grade color, units	0.1	1.2	- 0.1	0.9
Farinograph:				
Absorption, %	62.4	62.0	62.5	62.0
DDT, min	4½	4	6½	5¾
Stability, min	8	7	9½	9
Bread:				
Absorption, %	60	58	61	61
Loaf volume, cc	920	855	690	520
BSI, %	106	99	72	55

Source: Dexter et al. (1996). Analytical data expressed on 14% moisture basis.

Abbreviations: CL = cleaned by hand removal of obviously damaged kernels; AS = as harvested; DON = deoxynivalenol (vomitoxin); DDT = dough development time; BSI = baking strength index.

Table 4.

Effect of aerial spraying of Lorsban (37.4 L/ha) on some quality properties of midge-infested Neepawa hard red spring wheat.

Property	Unsprayed	Sprayed
Wheat:		
Midge damage, %	8.7	0.4
Protein, %	14.4	12.1
SDS, mL	56	62
Flour yield, %	72.4	74.2
Flour:		
Ash, %	0.56	0.48
Grade color, units	0.8	- 1.0
Farinograph		
Absorption, %	65.0	63.4
Stability, min	3¼	5¼
Bread		
Absorption, %	59	59
BSI, %	74	92

Source: Dexter et al. (1987).

Abbreviations: L/ha = liters per hectare; SDS = sodium dodecyl sulfate sedimentation test; BSI = baking strength index.

Table 5.

Protein content and particle size index of some Canadian wheat classes when fully vitreous, partly vitreous (piebald) and fully starchy.

Wheat class	Protein	PSI
	%	%
Durum:		
Vitreous	10.8	34.2
Piebald	9.1	35.3
Starchy	7.9	48.7
Hard Red Spring		
Vitreous	12.7	43.9
Piebald	9.9	43.2
Starchy	8.8	48.4
Hard Red Winter:		
Vitreous	11.5	52.0
Piebald	9.7	52.8
Starchy	8.5	57.6
Canada Prairie Spring		
Vitreous	12.1	55.4
Piebald	9.4	54.3
Starchy	8.3	58.3

Source: : Durum data from Dexter et al (1989); other data from Edwards and Dexter (unpublished).

Abbreviations: PSI = particle size index.

Table 6.

Effect on milling and baking quality of various proportions of frost-damaged Canada Feed wheat admixed with No 1 CWRS wheat.

Property	100% Feed	30% Feed	15% Feed
Wheat:			
Grinding energy, Whr/kg	30.6	26.6	24.1
Flour yield, %	69.7	73.9	73.6
Flour:			
Ash, %	0.56	0.52	0.48
Grade color, units	4.5	2.5	1.7
Protein, %	12.0	13.2	13.5
Starch damage, FU	50	35	32
Farinograph			
Absorption, %	67.7	65.2	64.5
DDT, min	2	6½	6¼
Bread			
Baking absorption, %	63	64	64
Loaf volume, cc	705	920	940
BSI, %	90	105	105

Source: Dexter et al. (1985). Analytical data expressed on 14% moisture basis.

Abbreviations: FU = Farrand units; DDT = dough development time; BSI = baking strength index.

Table 7.

Quality evaluation of artificially dried CWRS wheat.

Property	Undamaged	Heat damaged
Wheat:		
Test weight, kg/hL	77.7	77.5
Flour yield, %	74.8	74.5
Flour:		
Protein, %	12.7	11.3
Wet gluten, %	36.7	30.5
Wet gluten/protein	2.89	2.70
Ash, %	0.48	0.47
Grade color, units	0.4	0.3
Farinograph		
Absorption, %	65.2	64.7
DDT, min	9¾	1¾
Bread		
Absorption, %	64	61
Loaf volume, cc	820	595

Source: Preston et al. (1989).

Abbreviations: DDT = dough development time.

Composites of commercial rail carlots visually qualified for No 3 CWRS. The damaged carlots were downgraded to Canada Feed by the GRL heat-damage monitoring program.

Table 8.

Effect of moderate mildew damage on the quality of Canada Eastern White Winter (CEWW) wheat at maximum levels tolerated for various grades.

Property	No 1 CEWW	No 2 CEWW	No 3 CEWW
Wheat:			
Test weight, kg.hL	78.2	77.2	75.9
Falling number, sec	255	170	105
Flour yield, %	73.7	73.1	72.6
Flour:			
Ash, %	0.43	0.41	0.41
Grade color, units	-1.6	-0.7	-0.3
Protein, %	7.8	7.9	7.8
AWRC, %	65	66	65
Alveograph			
P (ht. X 1.1), mm	21	22	21
Length, mm	160	134	136
W X 10^3 ergs	62	60	56
Cookies			
Spread, mm	83	82	81
Ratio, spread/thickness	9.4	8.7	8.7

Source: Dexter (unpublished data). Analytical data expressed on 14% moisture basis.

Abbreviations: AWRC = Alkaline water retention capacity; P = pressure, W = work.

Table 9.

Effect of black-point on the quality of Canada Western Red Spring (CWRS) wheat.

Property	No 1 CWRS	No 3 CWRS	Canada Feed
Wheat:			
Black-point, %	0	5	40
Test weight, kg.hL	79.3	79.6	79.8
Flour yield, %	74.0	73.2	73.0
Flour:			
Ash, %	0.48	0.48	0.47
Grade color, units	1.0	1.2	1.2
Protein, %	14.9	14.9	15.3
Farinograph:			
Absorption, %	64.8	64.9	65.5
DDT, min	5½	5¼	5¾
Bread:			
Baking absorption, %	68	68	68
Loaf volume, cc	985	1000	1010

Source: Dexter and Preston (unpublished data). Analytical data expressed on 14% moisture basis.

Abbreviation: DDT = dough development time.